MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

INDIA.

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PREFACE.

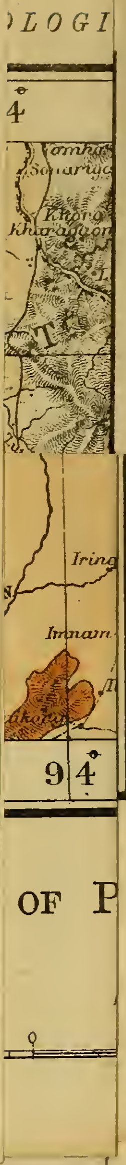
In extenuation of the incompleteness of the following Report, I would wish my readers to bear in mind the circumstances under which the observations on which it is based were made. Not only is the country so densely covered with vegetation, that for whole days one may march without seeing a single rock; not only is vegetation so dense that it is impossible for the most part to leave the narrow foot-path; not only is the structure of the country complicated and without any beds of marked individuality by which this structure could be unravelled, but my movements had necessarily to be guided by political exigencies rather than by geological necessities.

In a country partly depopulated and for the rest inhabited by savages of doubtful temperament, and where one's presence is decided by the accidental and temporary presence of an armed force brought there for objects among which geology, if regarded at all, is considered last of all, one cannot enjoy the same freedom and ease of movement as in the more quiet and settled districts of British India.

To Colonel J. Johnstone, Political Agent at Manipur, and to Mr. R. B. McCabe, C.S., Deputy Commissioner of the Naga Hills, I owe my sincerest thanks for the assistance I received at their hands.

R. D. OLDHAM.

Geological Survey Office;
Calcutta, 31st July 1882.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MEMOIRS

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GEOLOGICAL SURVEY OF INDIA.

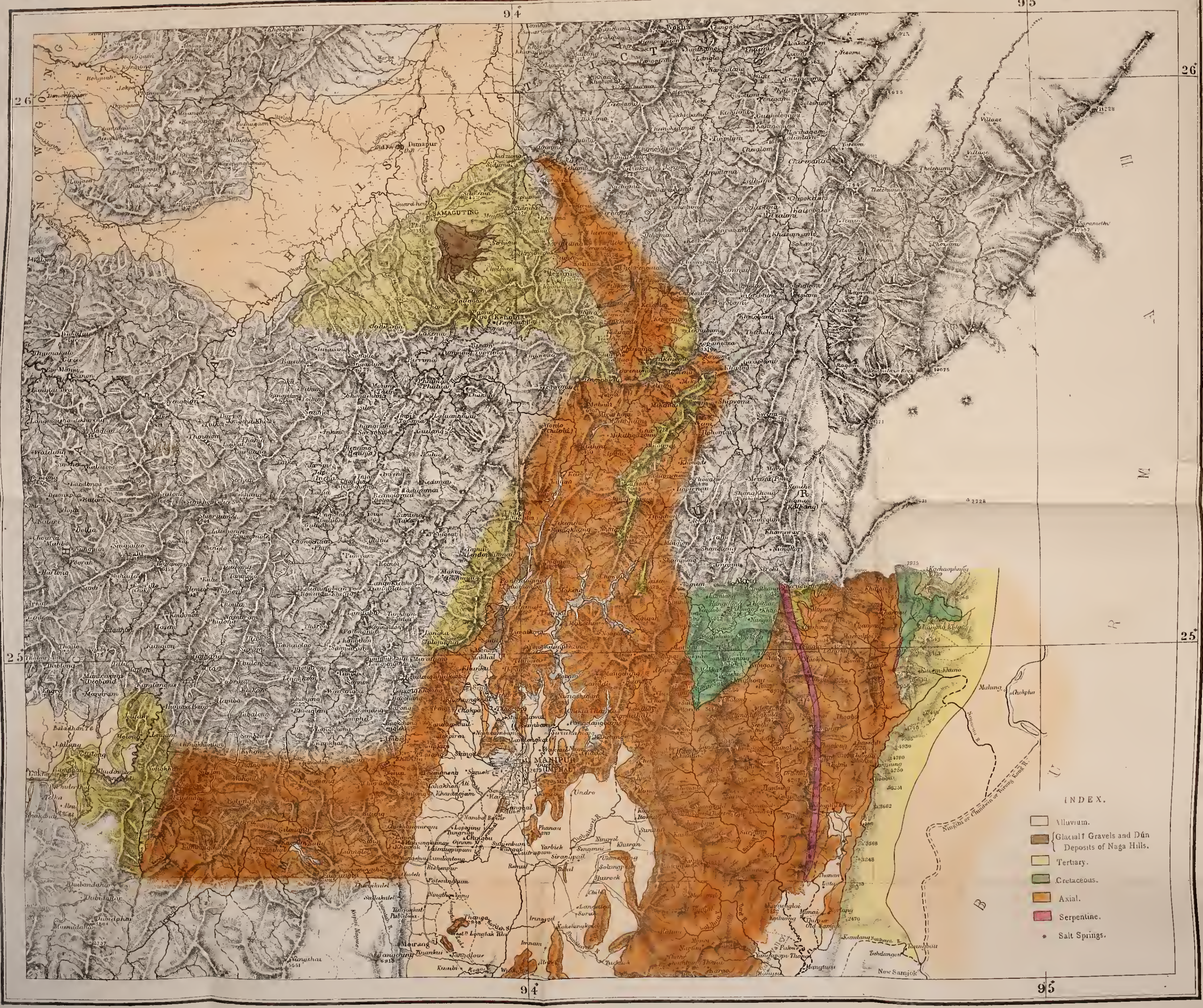
Report on the Geology of parts of Manipur and the Naga Hills, by R. D. OLDHAM, A.R.S.M., *Geological Survey of India.*

Previous information.

Of the geology of the country described in the following pages, comprising an area of some 1,800 square miles situated partly in the Tangkul-Naga hills, to the east of Manipur, the northern portion of the valley of Manipur and the hills inhabited by the Angami Nagas, together with the routes connecting those areas with each other, and the alluvial valleys of Cachar and Assam respectively, it may almost be said that previous to last November nothing was known.

R. B. Pemberton.
H. H. Godwin-Austen.

2. In the 'Report on the Eastern Frontier,' by Captain R. Boileau Pemberton, published in 1835, there are a few remarks on the economic minerals of Manipur, but it was not till Major (now Lieutenant-Colonel) Godwin-Austen visited this tract in charge of a survey party during season 1872-73 that any information of scientific value was obtained. The geological observations made by him were published partly in the official report on the Topographical Surveys for 1872-73, and partly in a paper on the evidence of past glacial action in the Naga Hills, published in the Journal of the Asiatic Society of Bengal, volume XLIV, pages 209—213. Besides these published observations, he noted on a map, by shades of colour, the rocks found in various localities of these hills; this map, deposited in the Office of the Geological Survey, though fragmentary and



GEOLOGICAL SKETCH OF PARTS OF MANIPUR AND THE NAGA HILLS.

Scale 1 Inch = 8 Miles.

incomplete in itself, has, taken in conjunction with and explained by my own work during the past season, enabled me to colour in a large area I should otherwise have been compelled to leave blank.

Method of description adopted.

3. In the following description I shall proceed in order of the various formations seen, commencing with the oldest; as the method of description by localities, while more convenient in the case of traverses would be very inconvenient when describing the connecting surveys I was able to make.

Older series.

4. I will therefore commence with a series of slates, sandstones and quartzites, which occupies the greater part of the area visited, and which I will provisionally call the 'older series,' deferring for the present the consideration of its age or title to a separate designation.

General description.

5. These beds were met with for the first time shortly after passing the Mukru river, on the road from Cachar to Manipur, where, two miles after crossing the river, the steady north-10°-east strike of the upper tertiaries suddenly ceased, and rocks, not at first very distinctly different in appearance, came in with a dip constantly changing in direction and amount, but settling down on the crest of the Kala Naga ridge to a south-easterly dip, which near the crest is 60° but as the road sinks down into the Barak valley is seen, while continuing steady in direction, to gradually decrease till in the bed of the Barak the strata are quite horizontal; this horizontality continues up the eastern slope of the Barak valley for some 1,000 feet, and here the series contains some beds of almost pure pipeclay. Beyond the village of Ballung (Bolongdoay) the dip again becomes south-east at 20°, and from here to the bed of the Irang the dip is constant to either south-east or east-10°-south, and generally about 20°. In the Irang the rocks are once more horizontal and continue so about half-way up the eastern slopes, whence they have a low dip to the west, all the way up to the crest of the ridge. After leaving the valley of Mapum the strike, though at first north and south, soon turns round to north-east and south-west, which, with local irregularities, continues with

a south-easterly dip to the bed of the Laimatak. On the ascent from the Laimatak there is a series of grey slates too decomposed for the dip to be distinguishable, but towards the crest sandstones come in at an E. N. E. dip, which continues as far as the alluvium of the valley of Manipur.

General description continued.

6. To the east of the valley, I found a great series of slates and quartzites with an easterly dip, generally with some north in it, which continued till the village of Tusom was reached. Near Tusom there appears to be a fault with an upthrow to the east, and here the dip suddenly changes to west and west-north-west, which dips continue to the great serpentine intrusion west of Kungal thanna, to the east of which there is a strip of the slates which have a generally westerly dip. In the whole of this section which, though apparently an ascending one throughout by far the greater part must have several repetitions, whether by faults or folding, I have not been able to detect any separation of the beds into more than a single formation.

General description continued.

7. On the Chatik ridge quartzose beds are not uncommon and on the crest there are one or two exposures of indurated pipeclay. Under the scarp of the Kasom range, there are numerous exposures of green (chloritic) schists, probably metamorphosed by the intrusive dykes which are here not uncommon; in some of the streams tufa was abundant, but in only one place, close to the Kasom village, was limestone found *in situ*; the rock was a highly metamorphosed dark marble with white veinings. Below the village of Chamu Khuno in the bed of the Nelay Khong, there was an exposure of fine-grained red slates; in the country lying between Chamu Khuno, Kachao, and the Kachao phung, the rocks are peculiar, a hard red coloured porcelanous rock, probably a more metamorphosed form of the red slate seen under Chamu Khuno, and structureless grey siliceous beds often passing into pure chert were the prevailing types, besides these grey and whitish slates and impure steatitic beds were seen. Near the deserted village of Kachao, there is a considerable amount of interbedded volcanic

ash exposed, which has a dip to the south-west. Westwards from Chamu Kulel to Chingsao the rocks are for the most part grey slate with a westerly dip, a band of white slate with the joint-planes stained red, being exposed below Chamu, while on the opposite side of the valley some fragments of steatitic schist were found. From here to Khangoi, except where interrupted by the trap or newer overlying rocks, slates and quartzites of this same 'older series' continue.

General description continued.
Limestone near Kongui.

8. Below Khangoi village I found for the first time some beds which were distinguishable from the great mass of grey slates and sandstones with which they are interbedded. These were a series of red and green slates, perhaps 200 feet in thickness, in which there was a solitary band of calcareous nodules, succeeded by grey and arenaceous slaty shales. Between Khangoi and Kampui (Lambui of map), about a mile beyond the former, there is another exposure of limestone which is well seen on the spur above Khangoi thanna; there is a thickness of about 150 feet, in all of a fine grained brittle limestone breaking with an imperfect conchoidal fracture, the lower portion is pinkish, while the upper and thicker portion is a pure pale-grey weathering somewhat yellowish; where seen *in situ* the beds were vertical with a north-north-west and south-south-east strike, though in the cliff above the grey limestone seemed horizontal probably from some freak of weathering; this, however, is a purely local variation of strike. The limestone is followed by slates and sandstones, but on the Hungdung spur, it crops out again with a north-north-east and south-south-west strike, or even nearer north, the exact bearing could not be distinguished. In the bed of the Nung-shang-khong the slates and quartzites had a north by east and south by west strike. Beyond Kampui red and green slaty shales once more cropped out with a single band of limestone nodules, and beyond this to Susukameng the rocks were of the usual grey slate and quartzite type.

Synclinal or anticlinal.

9. We have here evidently the only indication I have been able to find of the structure of the country, for this repetition could only be due to either a synclinal or an

anticlinal fold of the rocks, and though from my own observations alone it would be impossible to decide which, we have fortunately the observations of Major Godwin-Austen who found exposures of limestone, evidently a continuation of the Hungdung exposure, along the Rapfo ridge and as he does not mention any limestone to the east of this we may conclude that the corresponding exposure is separated by a greater intervening distance than is the case in the Nung-shong-khong valley. To the south, again, on the Susukameng-Kungal section no trace of the limestone was seen, and, unless some red coloured slaty rocks exposed under Tangkul Hungdung represent them, the red and green shales were equally absent. We have then the two outcrops diverging towards the north; this might be due either to an anticlinal whose axis had been elevated on the north, or a synclinal whose axis had been elevated towards the south. But, as I shall have occasion to point out when treating of the distribution of the upper tertiaries, there are very strong reasons for assigning an elevation to the country to the south rather than the north of the Nung-shong-khong. We may adopt the latter hypothesis, which would place the limestones above the red shales. Corroborative of this conclusion we have the section under the Kasom range here, where as far as appearances go we have an ascending section from west to east, limestone was found immediately beneath the escarpment of the upper tertiaries, while to the west, and therefore below it, red slates were found; if, and I see little reason for doubting the conclusion, these beds are identified with those in the Nung-shong-khong, it is another proof of the superposition of the limestone on the red and green shales.

Two series or one.

10. But it still remains to discuss whether these limestones and coloured shales should be considered as belonging to the great series below them or should be separated, and if so, where the line of separation should be drawn. Now, if the pipeclay of Chatik and that in the Barak valley be on the same horizon, and if the identification of the limestone at Khangoi and Hungdung with that below the Kasom escarpment be correct, and the weight of probabi-

lity in favour of these suppositions is greater than that against them, we have a most decided case of overlap. Further, on the western slope of the hill on which Chamu Kulel is situated, and again both north and south of the Kayeng village, white shales are found; I am not prepared to identify these for certain with the indurated pipeclay of Chatik, but they are very possibly the same; if so, their occurrence in these positions is still further proof of overlap.

Indirect evidence. Volcanic ash.

11. Besides this more or less direct evidence, there is the indirect evidence of the contemporaneous volcanic deposits near Kachao, which being from their nature and composition probably derived from the same source as the great trappean intrusion of the neighbourhood would naturally be of later date than the rocks in which the latter was intrusive, thus pointing to the presence of rocks belonging to at least two series. Unfortunately this argument is somewhat double-edged, for of all the rocks that I saw few were more metamorphosed than those immediately under the Kasom range, which I have conjecturally identified with the limestone and coloured shales of Kongui. This fact is explicable on the hypothesis that the beds among which the volcanic ash was found interstratified are but higher beds of the same series in which the limestone is near the base; and bearing in mind the jungly nature of the country, the disturbed condition of the rocks, the paucity of exposures, and the fact that I had not that complete command over my own movements necessary for the proper elucidation of a country having such a complicated structure as that under consideration, I am not able either to refute or substantiate such a conjecture.

Possibility of a third series.

12. The facts noticed in the above paragraph may point to a third series of rocks existing in this neighbourhood contemporaneous with the serpentine intrusions, and newer than either of the other two above noticed.

Demarcation of series, obscure.

13. Having thus, as I believe, proved that the older should be divided into at least two distinct series, there remains the important problem of where to draw the line between them, and to this I regret to say I see no hope of a solution; but

bearing in mind that the rocks of the Chatik ridge almost certainly belong to the older series, the line of demarcation between the two must in this neighbourhood be drawn not far below the limestone.

Ages of the two series.

Cretaceous?

Axials?

Not nummulitic.

Possible presence of nummulitics.

14. We now come to the very important question of the age of these two series respectively, and here we are balked at the outset by the entire absence of any trace of fossils, but notwithstanding this we can, I think, make a very good guess at the truth. The most important clue we have is the limestone of the Nung-shong-kong valley; this limestone is of a very peculiar character, and is absolutely identical in appearance and structure with a greyish limestone, which in Pegu has been classed by Mr. Theobald as of cretaceous age. If this identification be correct, the older of the two series would fall into its place with the 'axials' of the Arracan Yoma with which they agree in general characters, and be of triassic age. The only other clue we have to the age of these rocks is the presence of brine springs among them, which would point to a nummulitic age for the series; but seeing that, as I shall presently show, both are as may be inferred from the great unconformity at the junction vastly older than other rocks of miocene age, and as the brine springs occur in the older and not the newer of the two series, *viz.*, among the 'axials,' which under any circumstances could not be of nummulitic age, no great weight can be attached to this fact. But though these rocks cannot possibly be of nummulitic age, it is not improbable that other rocks of that age do exist in this district, for, as was pointed out in paragraph 11, there is possibly a third series which, lying between the cretaceous and miocene, would fall into its place among the rocks of eocene age.

Axials of North Manipur and the Naga hills.

15. I must now pass on briefly to describe the older rocks north of Manipur and in the Naga hills. The road from Manipur to Kohima lying almost along the strike of the rocks, little but grey and black slates with a north and south

strike and a high, generally vertical dip are seen. The ridge to the west of the Tiki valley, which culminates in the peak of Koupru, is capped by sandstones dipping to the west at about 40°; I was unfortunately unable to cross this ridge and examine the rocks, and therefore cannot of my own observation declare that these do not belong to the same series as the slates below, but have good grounds for separating them, and shall recur to this subject further on. In the Angami Naga country quartzites are found not unabundantly interbedded with jet black and grey slates; the strike of these is subject to occasional variations, but the irregularity of strike mentioned by Major Godwin-Austen is mostly superficial and due to the action of gravity on rocks whose joint planes have been loosened by weathering, for wherever the rock is exposed in a deep gully or valley, the strike is almost invariably north and south and the dip generally vertical. These rocks I refer without exception to the axial group of the Tangkul country.

Tipam group and axials.

16. This will be a favourable opportunity for a short digression to consider the relations of these rocks with those to the north in the Assam coal-fields. Here as described by Mr. Mallet, we have a series, the Tipam group, older than the coal-bearing rocks, the latter being of presumably nummulitic age; the former in general characters agree very fairly well with what I have classed as 'axials,' and are very possibly identifiable with them; this would be further proof, if proof were necessary, that the 'axials' are not of nummulitic age, and further assign a triassic age to the Tipam rocks.

Serpentine intrusions.

17. The trappean intrusions are confined to the eastern portion of the Tangkul country, and, if we except variations in texture, due to unequal rates of cooling, substantially all of but one kind. In describing these the words used in the Manual of the Geology of India when treating of the serpentine rocks of British Burma, may be transcribed almost verbally; the rock which occurs in dykes of varying sizes, the main axis of the intrusion forming a band some mile or two in breadth which runs throughout the whole

of the district examined in a general north and south direction, is a "characteristic dark-coloured serpentine; it frequently becomes a gabbro and contains bronzite, and is intersected by veins of gold-coloured chrysotile, or sometimes carbonate of magnesia;" the former was not found by me in Manipur. "The hills formed of serpentine may be distinguished at a distance by their barrenness; they appear to support little except grass and a few bushes." "In the neighbourhood of some of the larger masses of serpentine, the sandstones and shales are converted into greenstone and chloritic schist; but the effect varies, and in some instances the neighbouring rocks appear almost unaltered." All this is as true, word for word, of the serpentine of Manipur as of that in Pegu, and suffices to show the close similarity, if not identity, of the two which in hand-specimens are undistinguishable—a specimen brought from Burma by Mr. Theobald might, so far as appearance goes, have been broken off the same block as one brought by me from Manipur. It is further worthy of note that the mode of occurrence of this serpentine is the same as in Pegu, namely, that the serpentine outburst is confined not merely to east of the main range, but to the neighbourhood of the eastern limit of the hill rocks.

Date of outburst.

18. The date of this intrusion is, as I have already mentioned, posterior to that of the rocks to which I have assigned a triassic age, possibly also to those to which a cretaceous age has been attributed, and it is worthy of notice as an additional evidence that these rocks in which it is intrusive are not of nummulitic age that in Pegu the trap is nowhere found intrusive in rocks of undoubtably nummulitic age, and is hence probably of pre-nummulitic age.

Upper tertiaries.

19. The upper tertiaries are almost entirely confined to the borders of the region under consideration; the tract of them crossed on the road from Cachar to Manipur consists of argillaceous sandstones, sandstones and shales with a north-10°-east and south-10°-west strike; after leaving this band I did not again see the upper tertiaries to the east till the Angoching and Kasom ranges were reached.

Kasom escarpment.

The former I had no opportunity of examining, but as the two form one continuous escarpment broken through by the gorge of the Napunga whatever remarks I shall have to make as to the one will be equally applicable to the other. The Kasom ridge is composed of regularly bedded sandstones with, in the part accessible to observation, but few argillaceous beds; the thickness actually examined amounted to 1,500 feet, and in the hills on the Burma side of the crest there must be at least as much again, making a total thickness of over 3,000 feet. The sandstones have a moderate dip to the east, averaging about 20°, and in them plant remains and patches of coaly matter, which have given rise to the rumours of coal in the Angoching hills noticed by more than one of the Political Agents stationed at Manipur, are not infrequent; there is however but little hope of finding workable coal, the beds corresponding to the Nahan band of the Sub-Himalayas in which similar fragments of lignite have but too often raised false hopes of mineral wealth. To the north of the Kasom escarpment there is a low gap over which the sandstones have been denuded, and the crest of the ridge is occupied by rocks of (probably) cretaceous age; to the north of this gap rises the Kachaophung, which is structurally on the continuation of the Kasom ridge; here the rocks were similar to those of the Kasom, but in addition to abundant, though imperfect, plant remains, fragments of fossil resin were found in one of the beds, pointing to a probably contemporaneous origin for the amber dug in Upper Burma.

No coal.

Fossil resin.

Probable extension of upper tertiaries to the north.

20. Looking northwards from the Kachaophung the general appearance of the country is very different from that to the south, the hills being much barer and the southern faces often precipitous, the beds, too, looking from the south, seemed to have a gentle dip to the northwards. It would seem from this that the boundary of the upper tertiaries here trends westward, and that instead of merely occupying a narrow strip between the older rocks and the alluvium of the Ningthi valley, they

here spread out and occupy a broad tract of hilly country—a conclusion that is supported by the fact of upper tertiary sandstones capping the spurs on which Mapum and Poshing are situated, and by the fact of their coming in so far westwards as the Kopamedza range in the Angami Naga country.

Koupru ridge and hills north of Manipur.

21. I have already mentioned, paragraph 16, that the rocks capping the ridge to the west of the Tiki valley, appeared to rest unconformably on the slates below, and I find that Major Godwin-Austen identified them as tertiaries, and as he discovered marine bivalve fossils at Yemi and coaly matter in the sandstones of Laisen, both high ridges to the east, I have accepted his identification as almost certainly correct, and have coloured the map accordingly.

Patkai.

22. In the Naga hills district the same rocks are found, here somewhat more indurated, forming the culminating peaks of the Patkai range; the sandstones, which, where unweathered, might almost be called quartzites, and of which some beds weather with a beautifully rose-coloured surface contain numerous plant remains which, beyond the mere fact of their belonging for the most part to dicotyledonous plants are unfortunately undeterminable. Between Mao and Kohima the boundary runs in a straight line, too nearly north and south to be that of a natural escarpment of rocks whose prevailing dip is south-west, or even in some places south-south-west; from Kohima the boundary trends to the westward passing under Jotsoma, it curves round by Sachema and Karuphima whence it was not followed to the north.

Kopamedza.

23. To the east the upper tertiaries come in again within the boundary of British territory, the Kopamedza range being composed of sandstones with intercalated slaty rocks which have a rolling dip trending away to the east.

Fossils.

24. In only one position was I able to find any fossils other than plant remains, *viz.*, in the gorge of the Diphupani, where a broad road has just been cut, for the most part out of solid rock, and in two places beds containing numer-

ous specimens of a species of *Venus* were exposed. These shells, as well as the matrix in which they are imbedded, are undistinguishable from the fossils discovered by Mr. Theobald in the miocene beds of Prome, and are also very similar to the fossils found by Mr. Mallet in the Sub-Himalayan (Nahan ?) beds under Darjeeling.

Sub-recent.

25. I now pass on to the consideration of various local deposits of doubtful age, which I will class together as sub-recent, though it is not impossible that some at least may be of late pliocene age; they are (1) the 'Dun' deposits east of Samaguting; (2) the high level gravels, so-called morraines, of the Naga hills; and (3) certain high level gravels in Manipur territory. These I shall describe in the order above mentioned.

Samaguting duns.

26. Between the outermost ridge, that on which the station of Samaguting is situated, and the higher hills to the south-east, there are large tracts of comparatively low-lying gravel deposits, not unlike those of the duns of the Himalayas. One of these is traversed by the road to Kohima between Pherima and the Diphupani gorge; here there is exposed, in the deeper sections, a thickness of over 200 feet of sand and shingle of various degrees of coarseness forming terraces through which the streams have cut their present channels. These seem to be river deposits caused by a check in the gradient due to the elevation of the Samaguting ridge, deposition ceasing afterwards as the river cut down its bed in the Diphupani gorge.

High level deposits of the Naga hills.

27. In the valleys draining from the high peaks round Japvo, there are old high level river deposits which, from their composition, being a medley of blocks of stone of all sizes and, near the heads of the valleys at any rate, for the most part sub-angular, have been mistaken by Major Godwin-Austen for morraines.

Physical features of the country.

28. But before proceeding to a description of the deposits themselves, it will be well to devote a few words to a description of the more marked physical features of the hills among which they lie. If a straight line be drawn from Kohima

to Mao, we have, east of this line, a series of comparatively straight-crested spurs with rounded summits stretching eastwards at a height of four to five thousand feet till they drop into the valley of the Zullo, while to the west the spurs suddenly rise to some 7,000 feet whence sharp crested ridges run towards the west till they unite and culminate in the peak of Japvo at a height of 9,872 feet above the sea; thus we must limit the catchment areas of any glaciers which may have existed in these valleys to the comparatively small drainage to the west of the upper tertiary boundary.

Deposit in the Mizir valley.

29. Extending up the Mizir valley for about a mile beyond the line laid down in the last paragraph and ending abruptly in its vicinity, is a roughly triangular patch of gently and evenly sloping ground, through which the stream has cut a channel about 200 feet deep with steep and regularly sloping sides, on which is exposed a section of boulders, generally sub-angular, mixed with debris of every degree of fineness; as far as texture goes, it is just such a collection as might naturally be called a morraine; and if, as described by Major Godwin-Austen, the deposit really did come to an end just opposite Kigwema at a distance of four miles from its source, it is not impossible that a glacier flowing from a catchment area of about three square miles at most could have formed it.

Further extension.

30. But though this particular patch ends abruptly opposite Kigwema as correctly described, it is by no means the original limit of the deposit, whose further extension I will endeavour to describe with the assistance of the map. To the north of the villages of Kigwema and Mima, there is a long straight valley at the bottom of which is a broad gently sloping floor of from a quarter to half a mile in width, extending right up to the extreme head of the valley whence there is a sudden drop into the Mizir valley. This surface, which slopes about 200 feet per mile, would, if continued, coincide with that of the first-mentioned terrace at the head of the Mizir valley; and if any further proof of the original continuity of the two is required, it can be found in the small terraces which are to be seen under Kigwema, and

whose surfaces lie in the same continuous slope with that of the two larger remnants already described. From here the deposit continues to the junction of the stream flowing north of Mima with the Zullo, where it forms a broad flat surface that ends by sinking abruptly into the bed of the Zullo river; but even this is by no means its original limit, for, stretching down the valley as far as the eye can reach, a distance of at least four miles, there is a terrace evidently the remains of an old detrital deposit once continuous with that I have traced from the head of the Mizir valley, thus giving it an original extension of at least twelve miles, the greater part of which has been derived from an area of about three square miles; for on whatever theory we account for its origin, it is improbable that any great proportion was derived from the spurs to the east of the upper tertiary boundary, which, too, it is impossible to conceive as having served as collectors of snow from which so large a glacier could have been fed.

Evidence of non-glacial origin.

31. This extent of the deposit is in itself sufficient to preclude a glacial origin for it, but there are not wanting other facts equally if not more cogent, and all pointing in the same direction. Thus we have deposits precisely similar to those already described, and to which we must attribute the same cause of origin which are found, *e.g.*, in the Zumha valley, at a height of about 2,500 feet above the sea; and though some may be willing to believe that glaciers have descended to a level of 5,000 feet in these latitudes, there are, I fancy, very few capable of such an effort of faith as to accept the possibility of glaciers having descended to within 2,500 feet of the sea level within three degrees of the tropics, at any rate as long as any other explanation is possible. Nor do the gorges by which the drainage from the hills round Japvo escapes show any signs of glacial action; in that of the Mizir, which is the most open, so much so that the word gorge is hardly applicable, we have near its termination a low sharp-crested spur of solid rock, which from its shape can never have been subjected to the grinding of a glacier, running across the valley right up to the present bed of the stream; those of the other streams, *e.g.*, the Gaziarur (Kerhur-

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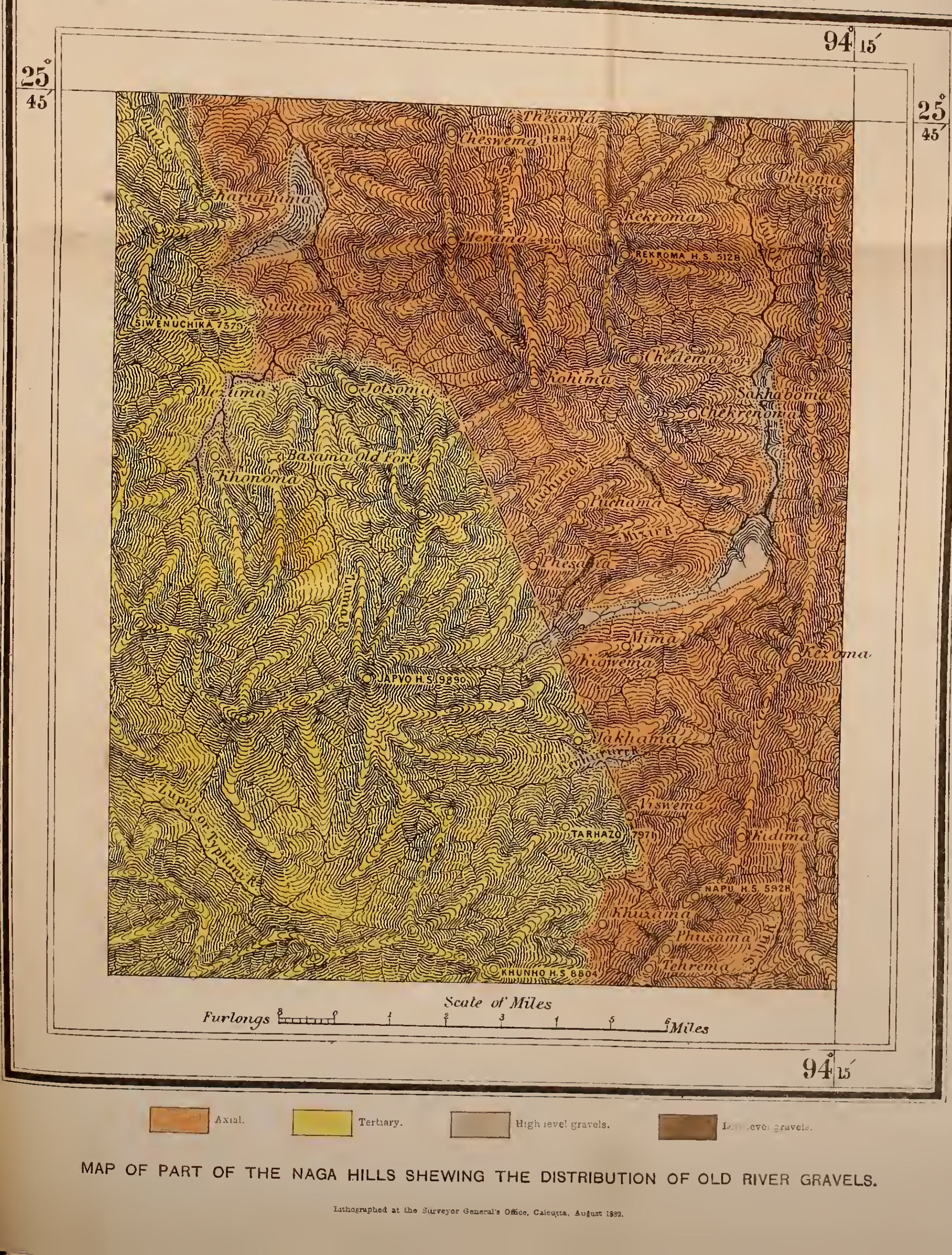


MAP OF PART OF THE NAGA HILLS SHEWING THE DISTRIBUTION OF OLD RIVER GRAVELS.

Lithographed at the Surveyor General's Office, Calcutta, August 1882.

rur), which flows to the south of Jakhama, are vertical-sided gorges of aqueous erosion without the least signs of glacial action.

Cause of origin.

32. But though I have, as I believe, shown the non-morrainal nature of these deposits, it is equally certain that they were not formed under existing circumstances for at present the streams are everywhere cutting into them, nor will any mere alteration of the levels causing a check in the gradients of the valleys account for the texture of the older deposits which differs markedly from those at present being formed lower down in the same valleys; but were the temperature decreased so as to kill off or largely diminish the amount of the forest on the slopes of Japvo, the rock would be disintegrated to a much greater extent than at present, and, if at the same time the rainfall increased, the greater rush of water carrying with it large quantities of detritus, would be able to carry with it the largest of the transported blocks now seen some miles from their original position; when this torrent debouched from its gorge into the more open valley below, the velocity being checked deposition would immediately commence, and gradually a long slope of boulders of every size mixed with gravel and sand begin to extend itself down the valley, its ultimate extent depending on the relative slopes of its surface and that of the valley, the former again depending on the relative proportions of water and debris forming the stream; nor need the fact that the larger blocks as seen near the head of the valley are sub-angular stand in the way of this explanation, for the masses of hard sandstone, originally angular, and which had not been subjected to the weathering that has softened the blocks now found lying on the surface, would need to travel some little distance before they became thoroughly water-worn; and it is a noticeable fact that as one travels down the slope of these deposits the larger boulders get more and more water-worn and at the same time smaller in size till few are left larger than what may be found at the present day washed down by existing streams.

33. This increased cold which I postulate, may of course be considered

as much evidence of a past glacial epoch as the actual existence of glaciers, but this concurrence of increased cold and increased precipitation could be produced under existing circumstances by an increased elevation of the Patkai, which I shall presently show, there is strong reason for believing was the case in geologically recent times. This increased elevation of course reduces the difficulties of explaining the possibility of glaciers having existed here, but the independent proof of the non-glacial origin of the deposits are so strong that it is unnecessary to enter into this question.

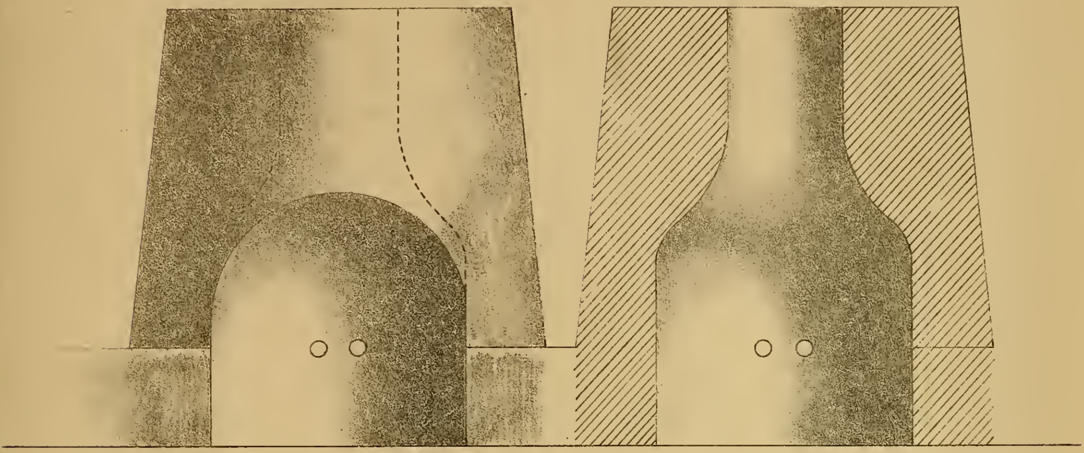
Glacial epoch *v.* increased elevation.

34. Between Viswema and Jakhama is another patch of similar deposits where we can plainly see the cause of the peculiar disposition of those near Kigwema. Here we have to the north of the Jakhama spur a small stream whose drainage area, for all practical purposes, lies entirely outside the upper tertiary boundary, and in which there are consequently no high-level deposits. To the south of the same spur is a stream which flows from the slopes of Japvo, and which, with another to the south, has formed a broad triangular surface now cut into by the same streams which originally formed it; but close to the village of Jakhama the deposit has been raised to within thirty feet of the crest of the spur as is shown in the outline sketch, Pl. 1, fig. 1, taken from Major Godwin-Austen's paper.

Jakhama deposits.

35. We have here an illustration of the history of the Kigwema deposits which are in a more advanced stage than those near Jakhama. There can be no doubt that originally the Mizir flowed along the foot of the spur on which Mima and Kigwema now stand; but that having raised the level of its bed to that of the saddle in the spur to the north, it poured over the rapid slope at the head of the small valley, and cutting down its channel established itself in its present course. From the small amount of deposit in the present Mizir valley and the low level at which it lies, I conclude that the conditions under which these deposits were formed must have passed away shortly after this catastrophe. The same

Alteration of drainage.



ELEVATION SECTION.

FIG. 2. MANIPUR IRON FORNACE

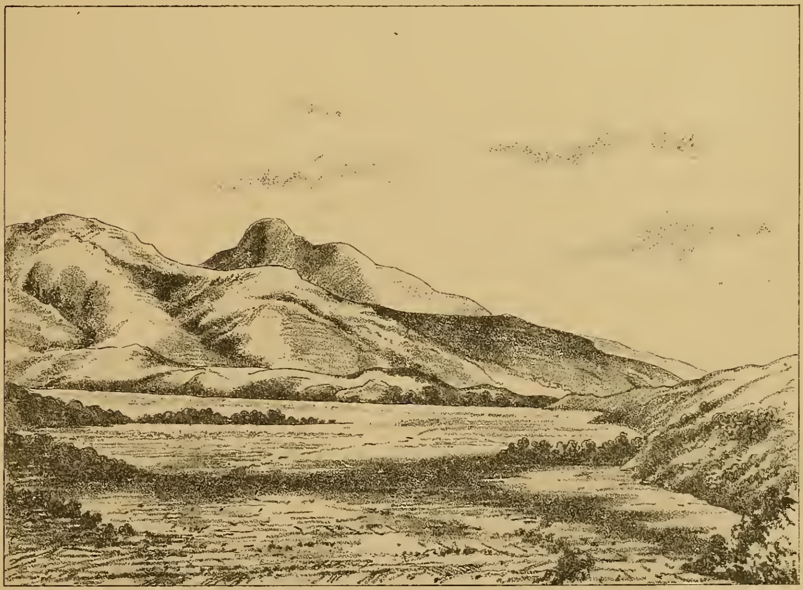


FIG:1. HIGH-LEVEL GRAVELS AT JAKHUMA.

thing would have taken place had the Gaziarur raised its deposits another thirty feet, and instead of flowing to the south of Jakhama it would have turned off to the northwards, where, through the ingenuity of the Nagas, a portion of its waters at present flow.

Other localities.

36. Deposits similar to the above described are also found below Khonoma, near Karuphima, and in Manipur territory they are to be seen in the valley up which the road to Kohima runs; but here, owing probably to the narrowness of the valley, they have been so much eroded that but little of their original sloping surface remains; here indeed it would be more difficult to prove that they were not morrainal, but the natural tendency to attribute their origin to similar causes to those of the others, added to the improbability of glaciers having ever descended to so low a level in these latitudes, is strengthened by the occurrence of small patches of almost level ground, gently sloping down the valley, which seem to have escaped the denudation that has elsewhere, in this valley, served somewhat to conceal the true nature of the deposit.

Tiki valley.

37. Entering the Tiki valley from Sengmai the road at first runs over the level alluvial surface of the Manipur valley; but before three miles have been traversed it passes into rolling stony ground sparsely covered with stunted trees and profusely scattered with boulders of slate and sandstone of all sizes and for the most part more or less sub-angular over which the road is carried till it makes a sudden drop to the level of the Tiki river; here the true nature of the tract just crossed is seen, for to the right is a narrow stretch of almost level ground through which the river meanders from side to side, while to the left abruptly rises a steep slope 100 feet in height, from the top of which the surface slopes gently upwards to the foot of the hills. It is on the north-east corner of this terrace that the thanna of Kaithamabi is situated. North of the thanna the terrace terminates, and a broad stretch of low land intersected by several streams slopes down to the Tiki; to the north of this, though no actual terrace can be detected there are remnants of an old high-level deposit which for the most part,

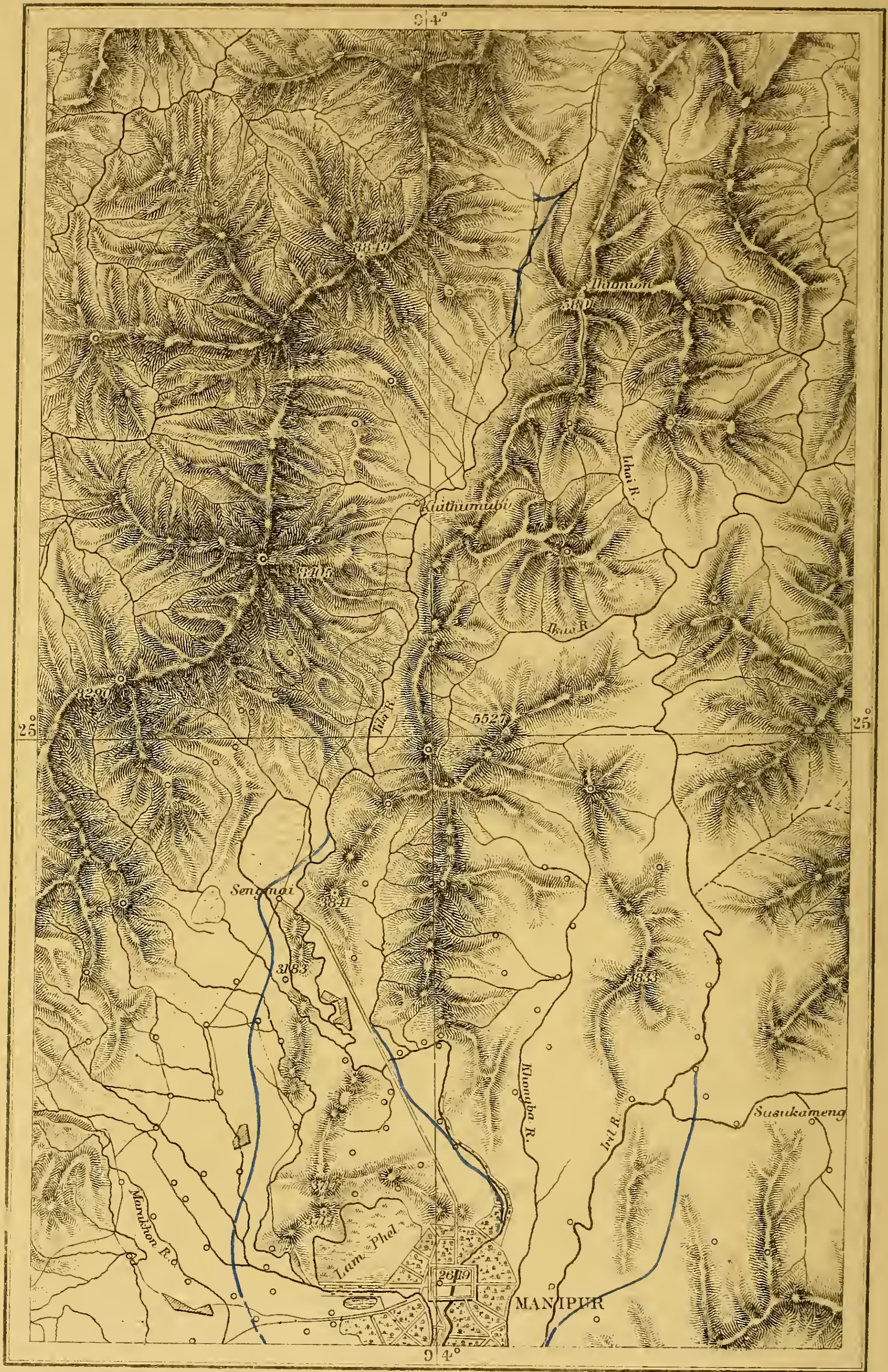
seem too elevated to have formed a continuous terrace with that to the south of the thanna.

Not lacustrine high level deposits.

38. This terrace might not unnaturally be taken as marking an old high-level littoral deposit of a lake, once filling the valley of Manipur, but not only is its texture not such as would be expected in lacustrine deposit, being not unlike that of the so-called 'morraines' of the Naga hills, and not only does it show in places near its very base evident signs of rivial action in its stratification and false bedding, but, were this explanation admissible, corresponding terraces should be found in all the other valleys draining into the same basin; so far from this being the case, I have seen no other similar terrace, in the valley of the Laimakhong there is no such feature, nor so far as could be detected in a distant view from Thunion is there any in the Iril valley; in both of these, as in all the small ravines flowing from the hills round the Manipur valley, the alluvium extends right up to the foot of the hills which descend in an even slope without any trace of a terrace. The only apparent exception that I can trace is in the Khongba valley; this I did not see myself, but a sketch is given by Major Godwin-Austen in which a most marked terrace is shown on the east of the valley; but from the appearance of the sketch and from the descriptive remarks in the text, I cannot but believe that Khongba is here a clerical error for Tiki.

Cause of origin.

39. Since then this feature is not general no general explanation is possible, but we must look to a local cause, which I take to be the same as that of the high level deposits of the Naga hills, that in past times in consequence of a colder climate, whether due to elevation or actual climatic change, the amount of debris brought down from the Koupru ridge was vastly greater than at present and choked up the whole valley, a subsequent rise of temperature causing an increase of vegetation and decrease of denudation enabling the Tiki once more to cut down the level of its bed. The open tract of low land north of Kaithamabi, which Major Godwin-Austen regarded as a filled-up lake, I take to be due to the almost



PART OF MANIPUR TO ILLUSTRATE THE ALTERATION OF DRAINAGE.

Blue lines indicate original courses of drainage.

Scale 1 Inch = 4 Miles.

5 4 3 2 1 0 5 10 Miles

complete removal of the talus by the streams flowing over it, which, as may be seen on the map, are much larger than those to the south. The numerous minor irregularities of the surface better accord with this theory than with the alternative one of its being an old lake gradually silted up.

Probable past extension of the Tiki valley.

40. But though the Tiki would probably have cut its bed down, as it actually has done, if the supply of water had decreased together with that of the debris, yet I hope to be able to show that it is not improbable that the stream may not only not have decreased, but may actually be greater now than at the time the high level terrace was formed. At the watershed between the Tiki and the Ngordai the road crosses over a low gap, hardly rising perceptibly, and passes over a fan brought down from the west by the stream marked on the map (opposite) as forming the head-waters of the Tiki, part of the drainage from which, if not part of the actual waters of the stream, flows into the Ngordai and part into the Tiki. This can only have originated by one of the streams having extended its valley at the expense of the other, nor is there much difficulty in determining which it is, for not only does the fan bear the appearance of having been formed by a stream originally flowing away to the north but the level of the Ngordai at four miles from this place is 400 feet higher than that of the Tiki at a similar distance from the same point, thus giving a more rapid fall and hence a more rapid erosion towards the south.

Bearing on theory of conversion of lateral into longitudinal drainage.

41. This has an important bearing on the much vexed question of the conversion of transverse into longitudinal drainage, for we have here one valley extending itself at the expense of and in opposition to another; and were the action to continue till the Tiki valley reached the junction of the Ngordai and the Barak, and consequently effaced the existence of the former, no inconceivable result, for the Barak is here 500 feet higher than the valley of Manipur, the waters of the Barak would be directed to flow along the Tiki valley to the south, and so transverse would be converted into longitudinal drainage.

Limit of Tiki valley during the formation of the high-level terrace.

42. Though I am not able to lay down the limit of the Tiki valley during the formation of the high-level deposits in either valley, I am inclined to place it, as marked on the map not far north of the low ground at Kaithamabi, for the high-level gravels there seem to be considerably higher, and more probably continuous with those of the Ngordai valley, than those to the south.

Deposits of the Ngordai valley.

43. In the Ngordai valley there is, extending from almost its very head to within a few miles of the Barak river, an alluvial flat but little raised above the level of the stream, and above this fringing the valley, more especially on its western side, the remains of an old high-level deposit. About three miles from the Barak the stream begins to cut into the alluvium, and at the junction there is an alluvial flat some hundred feet or more below the terrace, on which the Karong thanna is situated, and which seems to be a continuation of the alluvium higher up the valley showing that, owing to a lowering of its outlet in the Barak the Ngordai has within times, geologically recent, begun to cut into its old deposits; in its lower part this erosive action has now ceased, and it is again forming an alluvial plain at a lower level than its old one.

High-level gravels of the Thobal Turel.

44. The only other valley in which I saw any high-level gravels was that of the Thobal Turel, where there are terraces raised 80 or 90 feet above the central plain of the valley, which is itself raised well out of reach of floods, being at present cut into by the river. In this same valley I saw, what is probably the oldest of all the high-level grounds of this district, a small patch on the very summit of the Hungdung spur, and over 2,000 feet above the level of the river.

Alluvium of the Manipur valley.

45. The idea of the origin of the valley of Manipur common to all previous observers, who have ventured to speculate on its origin, is that it is an old lake basin filled or dried up; indeed, when seen from the summit of one of the surrounding hills nothing could be more natural, the broad flat plain dotted with

innumerable sheets of water and the low hills rising island-like from its surface all suggest the simile of a lake. Had this been the past history of Manipur, the present plains must either have originally formed the lake bottom, or have been produced by the gradual silting up of the lake and approximately mark the old water level. Major Godwin-Austen, the only one of previous observers who can be said to have had any knowledge of geology, rightly rejects the former, but adopts the latter supposition, in which I must differ from him, for it is impossible that, during the ages necessary for the gradual filling up of so large a lake, no terraces should have been formed by the inevitable cutting down of the outlet; but as has been mentioned no such terraces are to be seen, and consequently I am obliged to reject a lacustrine origin, for at least the upper beds of the Manipur alluvium. The Longtak lake, which has been appealed to as evidence of past lacustrine conditions in the Manipur valley, has no bearing on the question, as, in the absence of any information about its depth, it may be due to mere inequality in the rate of deposition of the alluvium.

Peculiarities of drainage.

46. A very marked peculiarity of the rivers flowing over the alluvium, and which is further proof of its rivial, rather than lacustrine, origin, is the manner in which many of them flow through gaps in the ridges which rise above the plain instead of round them as might have been expected; this feature is especially marked in the streams flowing into the north-west corner of the valley which all pass through the ridge that runs northwards from the town of Manipur. There can be but little doubt that this is due to the greater deposit of alluvium in the old valley of the Tiki, having risen to the level of the gaps in the ridge to the east, when the streams naturally flowed through these gaps into the lower level of the alluvium of the Imphal; so, too, the Iril having raised its alluvium till it found an easier outlet through a gap in the hills to the west, deserted its old course to adopt the one in which it now flows.

Similar deposits.

47. Alluvial plains surrounded by hills are not uncommon in this region. Besides that of Manipur and the small one in which the Kaopum thanna is situated, there are

the Kubo valley and the alluvial plains of the Ningti; it is evident, too, that Griffiths, in his tour from Assam to Bhamo, passed through several similar valleys, though he does not take any particular notice of the fact. The Kubo valley may not impossibly be a filled-up lake, for not only are there pretty distinct traces of an elevated terrace at its northern end, but in one of the small streams, not far from the northern limit of the alluvium, I discovered a bed of fine clay, almost pipeclay, which could hardly have been deposited by a stream flowing over an alluvial plain.

Kubo valley.

Dunseri valley.

48. The alluvium of the Dunseri valley, though it has probably shut out for ever the possibility of tracing the connection between the cretaceous and nummulitic rocks of the hills to the west and the coal-bearing rocks to the north-east, is not without interest of its own. That the valley of the Dunseri is a longitudinal valley, which has extended itself along not merely the strike of the rocks but along the line of weakness separating the two contrasting areas of the Mikir and Naga hills, there can be but little doubt, for the large open valleys through which the Jamuna and the now insignificant stream of the Langpher flow, carrying part of the drainage from the Dunseri alluvium into the Diyung, could not have been formed except by rivers draining from a much larger area to the east than they now do. But after the Dunseri had thus diverted the drainage from the east into its own channel, a subsidence of the land took place, causing the formation of the Dunseri alluvium. Though this subsidence was probably divided into several stages, some of them perhaps dating from pliocene times, we have indications that the last stage of all must have been of geologically recent date, for some eight miles below Mohendijua the Jamuna river falls over a barrier of gneiss; now until by subsidence of the land the alluvium of the Dunseri had been raised to the level of this barrier, all the drainage that now falls into the Jamuna to the east of or above it must have flowed into the Dunseri, but a river depositing alluvium always raises its banks and the surface of its waters above the level of the surrounding country so that after

the alluvium lying immediately to the east of what is now the barrier, and was formerly the water-shed of the Jamuna, was raised to its level, the first flood breaking through the banks of any of the affluents of the Dunseri naturally found an exit through the gap, and so struck out a new course for itself which it retained, and by a continuation of the same process, combined with an actual wearing away of the barrier, gathered to itself the waters of the other streams flowing down in its neighbourhood, and so part of the original drainage of the Jamuna, of which it had been robbed by the Dunseri, now flows once more in its original course. The large area of the Dunseri alluvium drained by the Jamuna is due partly to the well-known law by which alluvial plains slope from the banks of the depositing river, and partly to the cutting down of the barrier, thus enabling the streams to cut back their head-waters and divert to themselves more and more of the drainage of the Dunseri; this latter has, however, not yet occurred to any great extent, as may be seen by the very small depth of the channels in which the streams flow, and it is owing to this evidently very slight erosion of the barrier that I attribute a recent date to the escape of the present stream of the Jamuna in that direction, and it is not improbable that the subsidence which has caused this change in the drainage here was the same as that which put an end to the conditions under which the high-level deposits of the Naga hills were formed.

Mineral resources.

49. The region under description is very poor in minerals of economic importance, but iron, copper, gold, salt, lime, and edible earth are found in small quantities.

Iron.

50. Iron is found in more than one locality in the valley of Manipur; but so far as I know is confined to the swampy alluvial bays, where it is found in the shape of small pisolitic nodules of hydrated oxide of iron (bog iron ore) intermixed with clayey matter. The bed in which the ore is found is never at the surface, but covered with alluvium to the depth of two to five feet, and is itself from three to twelve inches thick. To procure it pits are dug, the barren soil above is thrown aside, and the band containing

the ore carefully collected and washed to separate the ore from the useless clay; the ore is then carried to the iron-maker's villages and there pounded in wooden mortars previous to reduction in the furnace.

Titaniferous iron ore (?).

51. Captain Pemberton in his report says that in the streams to the south of Thobal titaniferous iron ore is extracted, and that the exact locality of the deposit is discovered by thrusting a spear into the sand and examining the blade for particles of ore adhering to it. I cannot, however, but think that he was misinformed as to this, or misunderstood the process. He explains it by supposing the spear, which is always kept stuck upright into the ground, had acquired magnetic properties; this, however, could only be the case to a very slight degree, nor does it seem possible to me that, even if strongly magnetic, the fragments of ore could adhere to the blade while it was being extracted from the sand. I myself did not hear of any such process of discovering the ore, but it is possible that it may be followed, and that the yellowish-red streak of the ore on the spear blade betrays its presence.

Manipur iron furnace.

52. The furnace used in Manipur for the reduction of the ore differs not much in appearance, but greatly in principle, from those used in other parts of India. Externally it is a truncated cone, 18 inches high, about the same in diameter at the top and a few inches more at the base, perched on the edge of a terrace of earth four to six inches in height. The hearth varies somewhat, being larger in old furnaces than in new ones, but in the latter case is about 9 inches in diameter and the same in height; the tuyeres are inserted at the back at the level of the terrace on which the furnace stands and point downwards, while opposite to them is a roughly semi-circular aperture 9 inches broad and the same in height. Above the hearth the walls are thickened, and the central aperture is reduced to 6 inches in diameter: this structure will be easily understood from the sketch elevation and section in Pl. I, fig. 2, (page 16). When at work the blast from the tuyeres impinges on the hearth and passes out with all the products of combustion through the aperture in

front; the chimney above being kept full of charcoal and ore insures that the fire is continuously fed, but otherwise takes no part in the operation. From the above description it will be seen that the ore is practically reduced on an open hearth, and the Manipuri furnace would seem to show one of the first steps in the transition between the original method of reducing the ore in an open fire and its reduction in a scientifically-constructed blast furnace. Doubtless the Indian furnace is the descendant of such a structure, some inventive genius experimentally inclined tried the experiment of closing the aperture opposite the tuyeres and forcing the products of combustion to escape upwards through the chimney, and finding his experiment a success, inaugurated a new era in the reduction of iron.

Copper.

53. Copper is worked in the south-eastern corner of Manipur territory, the ore being obtained from the hills bordering the Kubo valley. I was not able to visit this locality, but was shown a specimen of malachite and copper pyrites mixed, said to have come from the Maku hill. I expect however that it really came from the first-mentioned locality, as I could get no exact information as to what part of Maku the ore was extracted from.

Gold.

54. Gold is washed in the sands of the Ningthi river, but not, so far as I was able to discover, to any great extent it is not found in Manipur territory.

Lime.

55. The supply of lime is very deficient. Manipur is supplied by the produce of the beds mentioned in paragraphs 7 (*et seq.*) which has to be carried three days' journey; here as elsewhere in India the solid limestone is not burnt, tufa being preferred. In the Naga hills no limestone has been discovered, nor do I consider it likely that any will be discovered at any rate within a reasonable distance of Kohima.

Edible earth.

56. In the valley of Manipur in a small tila to the left of the main road leading northwards from the city, there is exposed an unctuous clayey rock, which is dug out and sold in the bazaar, being esteemed a delicacy to which medicinal virtues are also attributed.

Salt.

57. Salt is in Manipur territory tolerably abundant; it is derived from brine wells. In evaporating the brine two distinct methods are followed, each spring being evaporated on the principle which has been found to be best suited. In some cases the brine is merely boiled down in open vessels and the resulting crystals wrapped up in small parcels in leaves; this form of salt appears to be deliquescent; but most of the Manipuri salt is treated in a very different manner; the brine is first concentrated in large earthenware vessels standing four feet or more in height and with sides over an inch in thickness but the final desiccation is performed in shallow metal dishes over a quick fire; the dishes are lined with green leaves and the brine poured on to them, as it solidifies more is added till a cake of half to three-quarters of an inch in thickness is formed, the brine is then dried off completely and the salt turned out in a meniscus shaped cake about nine inches in diameter and three-quarters of an inch thick. The salt prepared in this shape is not deliquescent, and the reason that this process is not uniformly followed seems to lie in the fact that the salt of some of the springs is deliquescent, in which case it could not retain its shape if formed into cakes.